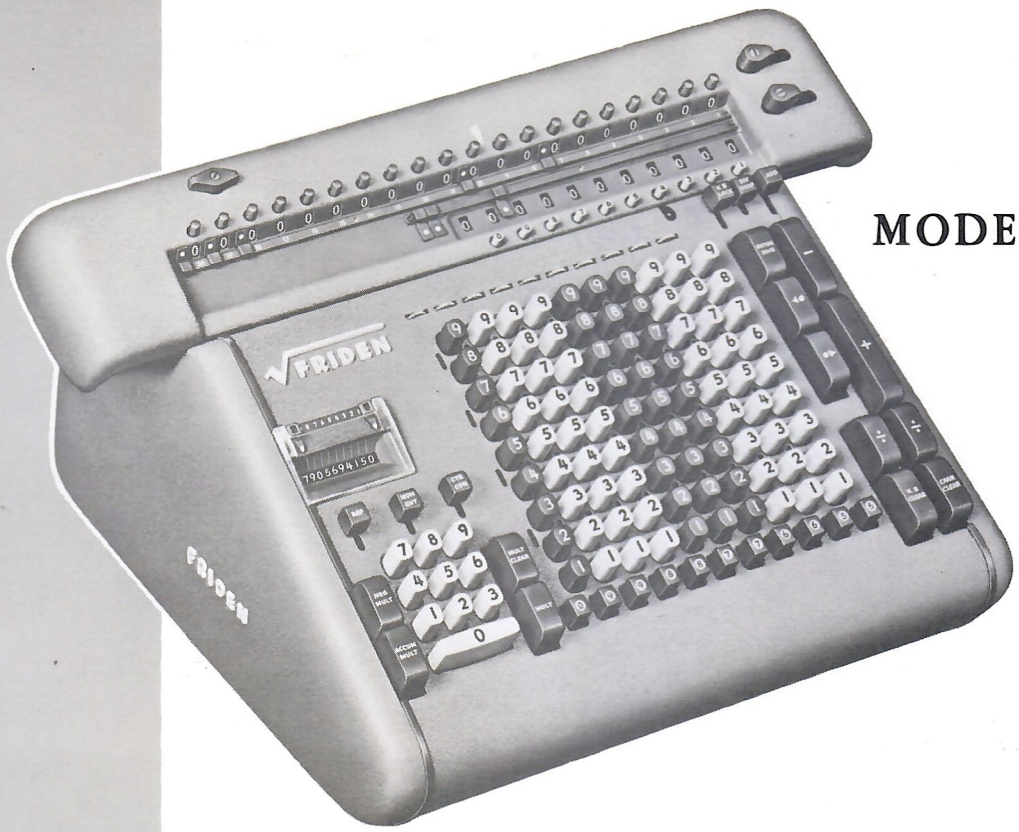
Friden CALCULATING MACHINE

MECHANICAL OPERATIONS



MODEL SRW

Insert this section into your brown covered Calculating Machine Operation and Adjustment Manual behind the yellow SRW divider.

This section replaces the obsolete orange covered Model SRW Manual dated 8-1-52.

Friden, Inc.
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Printed in U. S. A.

PREFACE

This section consists of the Model SRW Mechanical Operations and it replaces the obsolete orange colored SRW Service Manual dated 8-1-52.

In this section we explain how the "Fives Method" or 5 x Odd Integer is used to extract the Square Root and also how to do Square Root by manual operation. By learning the manual operation you will become familiar with the standard machine parts which are operated during the automatic operation on the Model SRW. This will assist you in understanding the operation of the extra control parts which consist of the Square Root mechanism and how these parts operate the standard machine plus knowing how to extract Square Root manually.

Study this section with care using the Model SRW. The Square Root mechanism is an extra control feature which is operated by the standard machine and also operates the standard machine.

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MECHANICAL OPERATION

$\sqrt{\text{RADICAND}}$

SQUARE ROOT WITH "FIVES METHOD" OR "5 X ODD INTEGER METHOD"

As the SRW uses the "Fives Method", the following is an explanation of this interesting method of extracting Square Root manually so you may know how this is accomplished, what parts are involved and be able to tie in these parts with the automatic operation.

The "Odd Integer Method" of extracting Square Root is based on the fact that the total of the odd integers added in their consecutive order is always the square of the consecutive number of the last odd integer added.

Consecutive Number	Odd Integer	Total Odd Integers		Square of
1	1	1	=	1
2	3	4	=	2
3	5	9	=	3
4	7	16	=	4
5	9	25	=	5
6	11	36	=	6
7	13	49	=	7
8	15	64	=	8
9	17	81	=	9

Since we can extract the Square Root by subtracting the successive odd integers, we can also extract the Square Root of five times a number, by subtracting five times the odd integers. This means that we multiply the number by 5 and then subtract 5,15,25,35,45,etc.

5	=	5 x 1
15	=	5 x 3
25	=	5 x 5
35	=	5 x 7
45	=	5 x 9
55	=	5 x 11
65	=	5 x 13
75	=	5 x 15
85	=	5 x 17
95	=	5 x 19

It will be noticed that in the above table, we have added 95, or 5 x 19, which is the maximum that has to be set on the keyboard in this method of extracting Square Root.

OVERDRAFT MUST BE OBTAINED

The "Fives Method" has one definite peculiarity. Five times each odd integer is subtracted until an overdraft occurs, but the keys on the keyboard that cause the overdraft remain undisturbed and are not changed after the overdraft has been restored except the '5' which is erased or moved to the next order to the right (see following examples on manual operation). On the SRW the overdraft is obtained by the standard division operation and the selection is retained by the Auxiliary Selection Slide.

It is important that you understand that Square Root extraction in each position must continue until the overdraft occurs. On a perfect square such as 144, the "Fives Method" is apt to be confusing until you understand that the overdraft must be obtained before the shift even when there is nothing in the upper dials.

SQUARE ROOT IN KEYBOARD SELECTION

At the termination of the extraction of the Square Root by the manual "Fives Method", the Square Root is already in the selection on the keyboard, ready to be used in multiplication, division, etc. On the SRW, with the Add Key up, the selection is retained.

$\sqrt{\text{RADICAND}}$
SQUARE ROOT WITH "FIVES METHOD" OR "5 X ODD INTEGER METHOD"

SQUARE ROOT COMPLETED BY DIVISION (MANUAL METHOD)

When half of the Square Root figures have been obtained, a touch of the divide keys will produce the balance of the Square Root by automatic Division, however only half of the Square Root will be held in selection on the keyboard when the root is completed by Division if the Add Key is up.

WHOLE NUMBERS IN SQUARE ROOT

The Square Root contains as many whole numbers as there are groups or partial groups of two figures each, to the left of the decimal in the radicand.
EXAMPLE: 625. = 6,25. answer 25., 4225. = 42,25. answer 65.

KEYBOARD POSITION OF DECIMAL RADICAND
(Carriage in extreme right position)

When the radicand is a decimal, set a decimal marker on the keyboard at 10. Place a decimal marker at 10 in the lower dials. This is the decimal point for the Square Root of a decimal.

Set the radicand on the left of the keyboard in relation to the decimal point at 10, thus .000225.

KEYBOARD POSITION OF RADICAND

When the radicand contains an even number of digits to the left of the decimal point, set the left hand digit in keyboard column 10. Thus 6250. is set as 6250.000000.

When the radicand contains an uneven number of digits to the left of the decimal point, set the left hand digit in keyboard column 9. Thus 625. is set as 0625.000000.

AUTOMATIC SQUARE ROOT WITHOUT REFERENCE TO THE DIALS

This method eliminates the necessity of watching the dials while manually extracting a Square Root. The operator depends upon the overdraft and bell. Therefore a high degree of speed is quickly attained.

THE "FIVES METHOD" (MANUAL OPERATIONS, EXAMPLES)

$\sqrt{625.} = 25$

Add Key and Division Stop down. (Retains selection and allows only one cycle Plus and Minus. This feature is not on Model SRW.) Counter Control Key down. (Reverses Counter on manual method; automatically accomplished on the SRW, Figure 6.)
Depress #9 Tabulator Key. (Permanently set on the SRW.)
Depress Enter Dividend Key. (Automatically accomplished upon depression of Square Root Key, Figure 1.)
Set Radicand (625.) on left of Keyboard as 0625. (Set as 625. on SRW.)
Multiply 0625. five times (Plus Key) = 03125. (Automatically accomplished on the SRW, Figures 3 and 4.)
Clear Counter Dials. (Counter blocked out by Enter Dividend blockout on the SRW.)
Clear Keyboard. (Automatically accomplished on the SRW, Figure 5.)
Set "5" in 9th. Keyboard column. ("5" entry set automatically in selection on the SRW, Figure 8)

Accumulator Dials show 03125. Keyboard shows 05.
Proceed as follows.

KEYBOARD	MANUAL OPERATION	ACCUMULATOR DIALS	COUNTER DIALS
05	Minus. (Same as Subtract cycle in Division on the SRW.)	02625	1
15	Minus. (Same as Subtract cycle in Division on the SRW. The "1" in 10th. column is entered automatically in selection on the SRW. Figures 9-10-11.)	01125	2
25	Minus. (Overdraft-same as Division overdraft. The "2" in 10th. column is entered automatically in selection on the SRW. Figures 9-10-11.)	98625	3
25	Plus. (Restore-same as Division restore.)	01125	2
25	Left shift. (Same as Division Shift.)	01125	2
20	Release "5" in 9th. column. (Automatic on the SRW. Figure 12.)	01125	2
205	Set "5" in 8th. column. (Automatic on the SRW. Figure 12.)	01125	2
205	Minus. (Same as above.)	00920	21
215	Minus. (Same as above.)	00705	22
225	Minus. (Same as above.)	00480	23
235	Minus. (Same as above.)	00245	24
245	Minus. (Same as above.)	00000	25
255	Minus. (Same as above.)	99745	26
255	Plus. (Same as above.)	00000	25
255	Left shift. (Same as above.)	00000	25
250	Release "5" in 8th. column. (Same as above.)	00000	25
2505	Set "5" in 7th. column. Minus (Overdraft) Plus (Restore) Left shift Release "5" from 7th. column and set in 6th. column and repeat above operation until the Carriage reaches first position and the "5" is released from the 1st. column. (The "5" entry progresses to the right as the Carriage shifts to the left on the SRW the same as it does on manual operation.)	00000	25
25		Square Root	25

TERMINATION OF ROOT IN CARRIAGE POSITION 1

When a root has been completed in Carriage position 2, release the "5" from column 1, shift the Carriage and subtract 0,1,2,3,4,etc., until the overdraft occurs and then restore.

When you memorize the steps required to extract Square Root as shown on the examples as above and below, you will be able to extract the square of any number plus becoming familiar with the mechanical operation involved during the automatic operation as accomplished on the Model SRW.

$\sqrt{144} = 12$

0144.000000 x 5 =
00720.

05	Minus	1
15	Minus (Overdraft.)	2
15	Plus (Restore.)	1
15	Left Shift	1
10	Release "5"	1
105	Set "5" in column 8	1
105	Minus	11
115	Minus	12
125	Minus (Overdraft)	13
125	Plus (Restore.)	12
12	Release "5"	12

$\sqrt{1225.} = 35$

1225.000000 x 5 =
06125.

05	Minus	1
15	Minus	2
25	Minus	3
35	Minus (Overdraft.)	4
35	Plus (Restore.)	3
35	Left Shift	3
30	Release "5"	3
305	Set "5" in column 8	3
305	Minus	31
315	Minus	32
325	Minus	33
335	Minus	34
345	Minus	35
355	Minus (Overdraft)	36
355	Plus (Restore.)	35
35	Release "5"	35

DECIMAL NUMBERS

$\sqrt{.000225} = .015$

.0002250000 x 5 =
0.001125

05	Minus (Overdraft.)	.1
05	Plus (Restore.)	.0
05	Left Shift	.00
00	Release "5"	.00
005	Set "5" in column 8	.00
005	Minus	.01
015	Minus (Overdraft.)	.02
015	Plus (Restore.)	.01
015	Left Shift	.010
010	Release "5"	.010
0105	Set "5" in column 7	.010
0105	Minus	.011
0115	Minus	.012
0125	Minus	.013
0135	Minus	.014
0145	Minus	.015
0155	Minus (Overdraft.)	.016
0155	Plus (Restore.)	.015
015	Release "5"	.015

SRW SPECIAL FEATURES

1. The number 9 Tabulator Key is locked down permanently. Therefore, unless the Keyboard Lock Lever is pulled down, the Carriage cannot be tabulated without getting an entry.

2. There are no Zero Keys on the Keyboard. To release a Key in any column, tap lightly on another Key in that column.

3. The Keyboard Lock Bar locks the Keyboard in Square Root operation by being actuated to the left. When the Keyboard Lock Lever is pulled down, for standard operations, the Lock Bar moves to the right.

4. The Keyboard will clear if the Add Key is down and the Division Stop is used in standard Division operation.

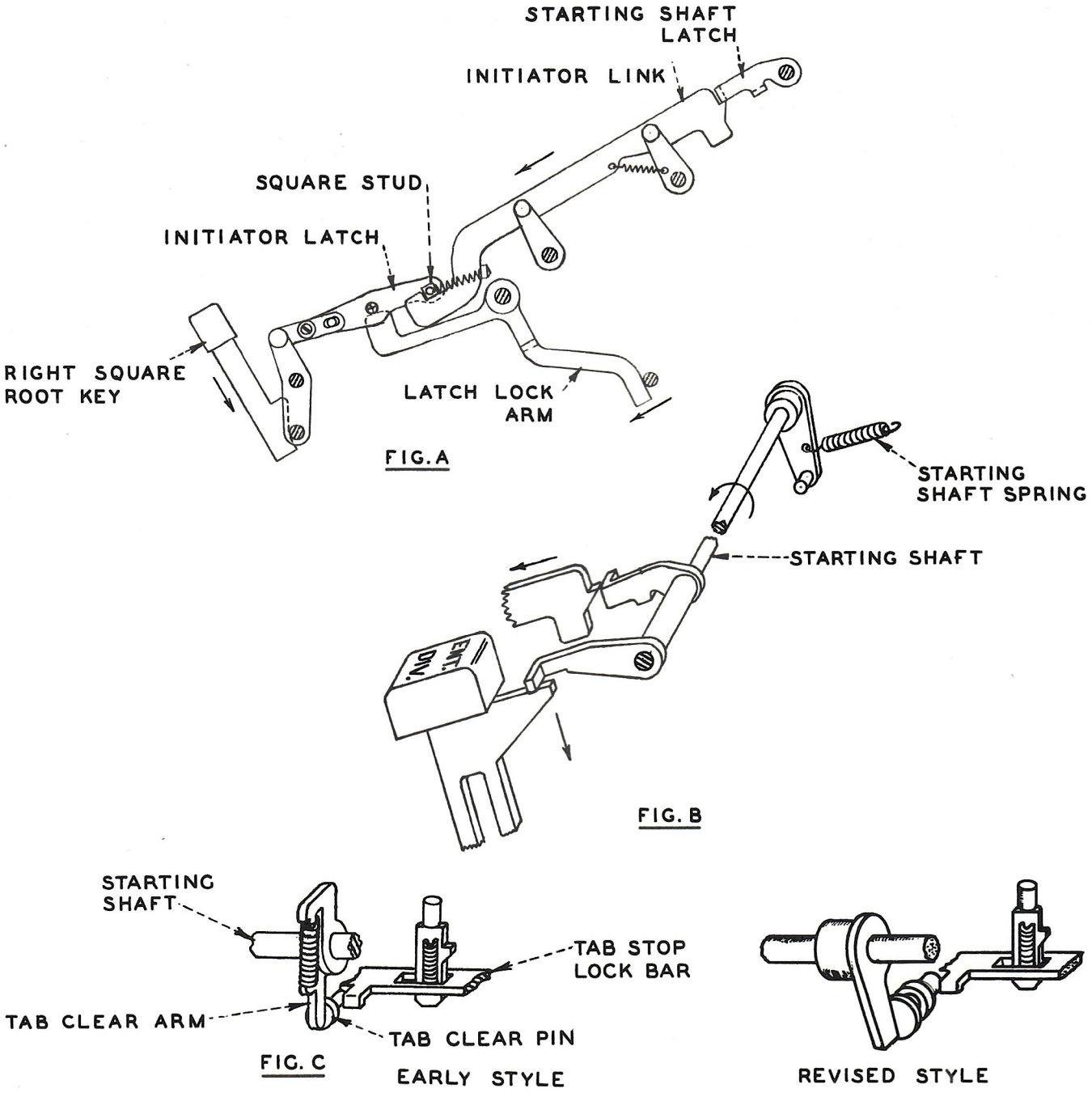


FIG. 1 STARTING SHAFT DELATCHING: FIG. A. The depression of the right square root key causes the square stud of the initiator latch to pull the initiator link from under the starting shaft latch. The starting shaft spring, FIG. B. actuates the starting shaft to depress the enter dividend key and start the machine in tabulation, and to actuate the tab clear arm and tab clear pin, FIG. C. As the carriage shifts to the left, the tab clear pin is contacted by the tab stop lock bar so that any depressed tab stop is released before the carriage shifts to the right.

When the clutch releases, the latch lock arm raises and disengages the initiator latch. This occurs whenever the clutch releases.

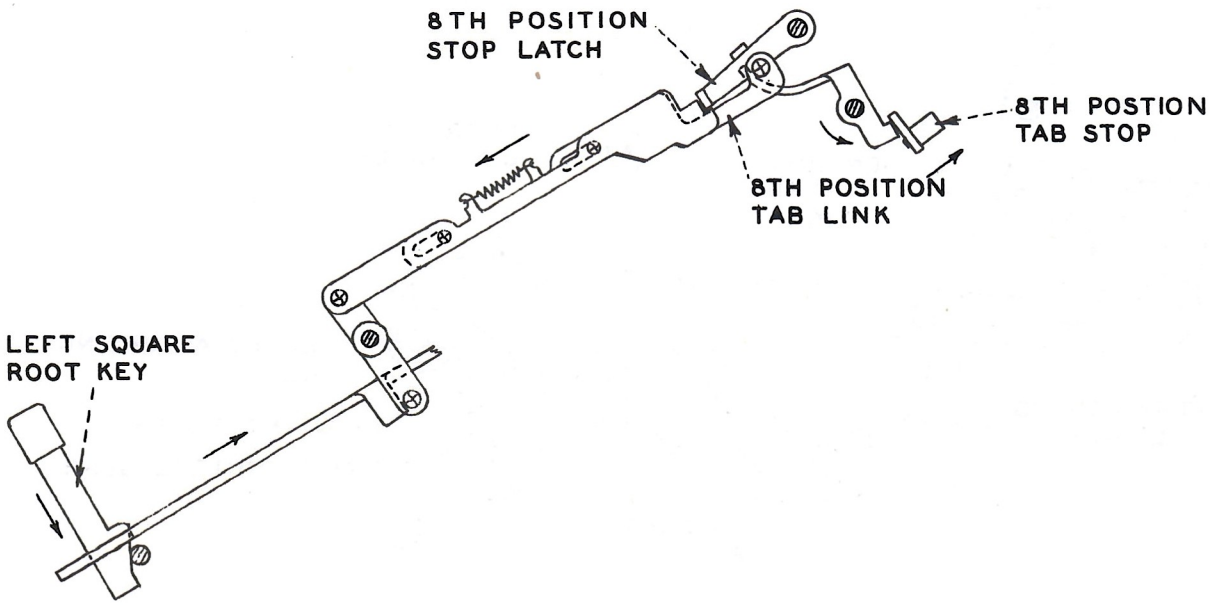


FIG. 2. SETTING OF 8th POSITION TAB STOP: The depression of the left square root key causes the same action as in FIG. 1, plus actuating the 8th position tab link forward to set the 8th position tab stop. The tab stop is held in position by the 8th position stop latch until the completion of the enter dividend operation.

The 8th position tab link is spring loaded to prevent damage should the 8th position tab stop be restricted by a carriage tab stop.

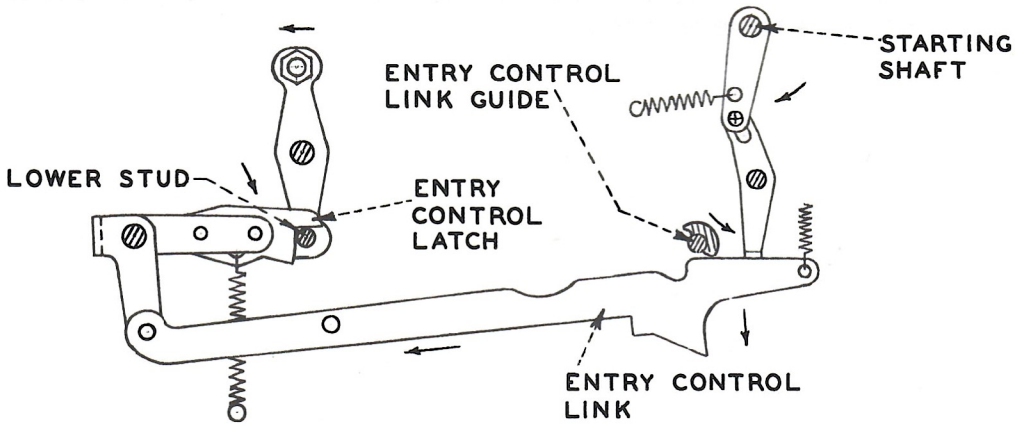


FIG. 3. POSITIONING OF ENTRY CONTROL LINK AND ENTRY CONTROL LATCH: When the starting shaft is actuated, the entry control link is depressed and delatched from the entry control link guide. The entry control latch positions on top of the gate arm lower stud. When the carriage reaches its position, the add-sub gate is actuated into plus position by the tabulation mechanism. The entry control latch drops by spring tension behind the gate arm lower stud. The entry control latch holds the add-sub gate into position during the radicand entry.

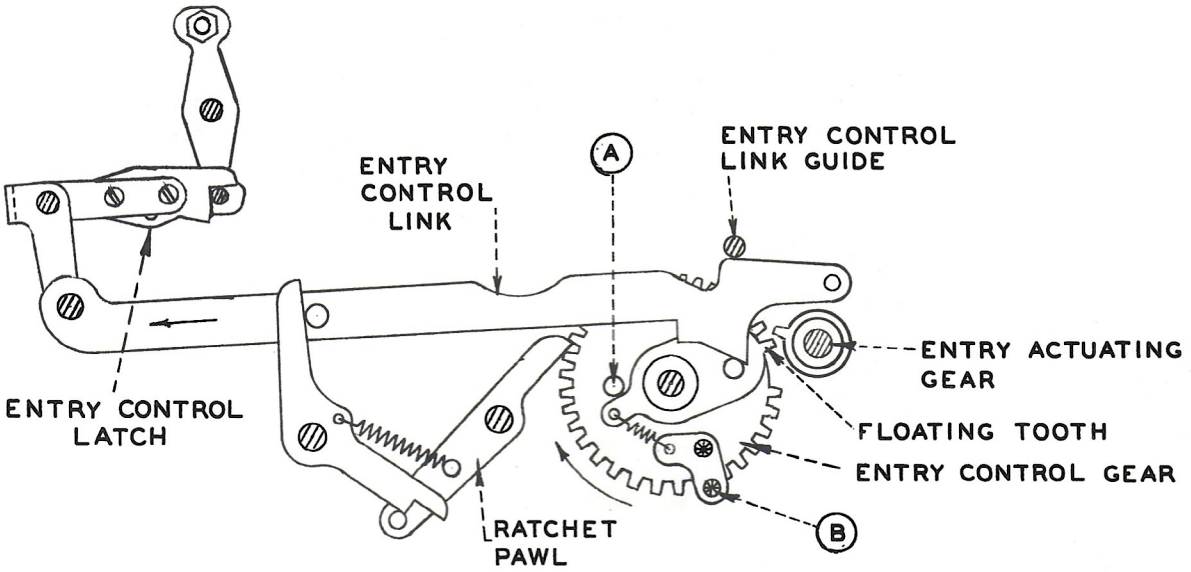
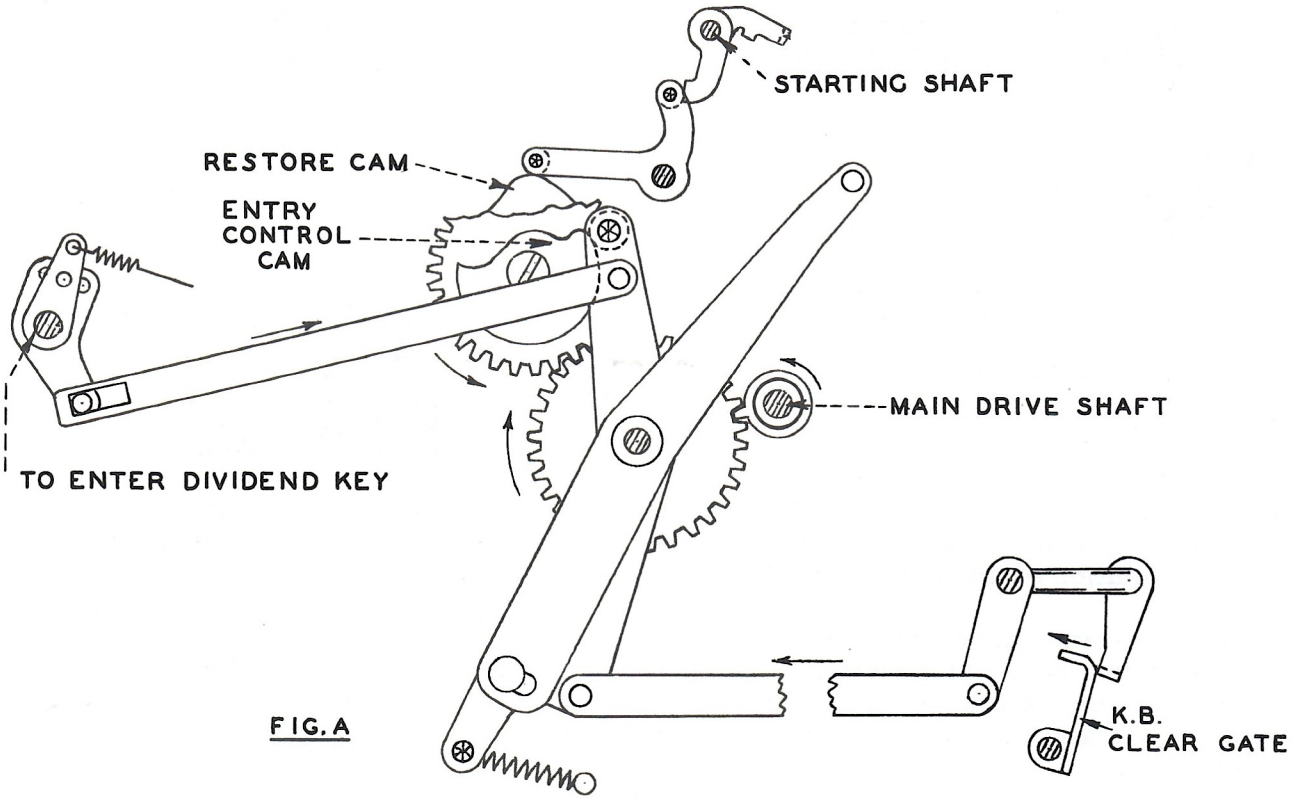


FIG. 4. POSITIONING FLOATING TOOTH AND ROTATION OF ENTRY CONTROL GEAR: When the entry control latch drops into position, the entry control link moves rearward and cams the floating tooth into position to be contacted by the entry actuating gear. The drive shaft rotates five times to multiply the radicand by five. Each drive shaft revolution causes the entry actuating gear to rotate the entry control gear two teeth.

On the 5th revolution, stud A restores the entry control link onto the entry control link guide so the entry control latch will release the add-sub gate and allow it to restore to home position.

On the 6th revolution of the drive shaft, stud B disables the ratchet pawl allowing the entry control gear to restore to home position.



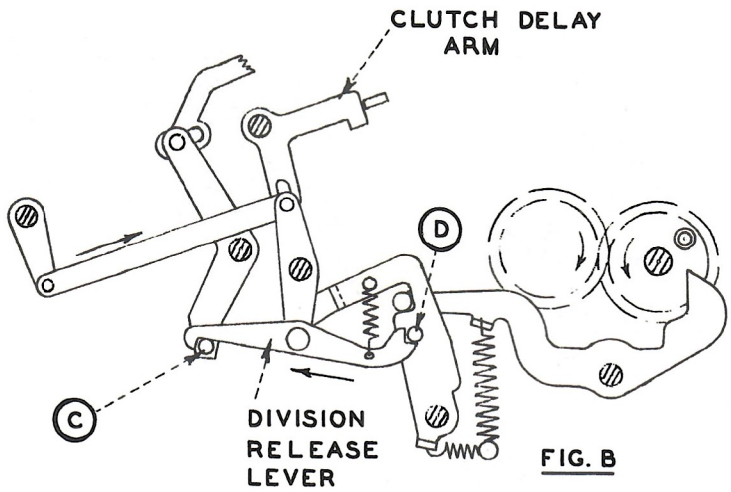


FIG. 5. ACTIONS BY ENTRY CONTROL CAM: FIG. A. On the 4th revolution of the drive shaft the starting shaft restore cam relatches the starting shaft. On the 5th revolution of the drive shaft the entry control cam causes:

(1) the releasing of the enter dividend key, FIG. A.
(2) the clearing of the keyboard, FIG. A.
(3) the positioning of the division release lever to studs C and D and the positioning of the clutch delay arm, FIG. B. The clutch delay arm keeps the clutch released when the enter dividend key releases.

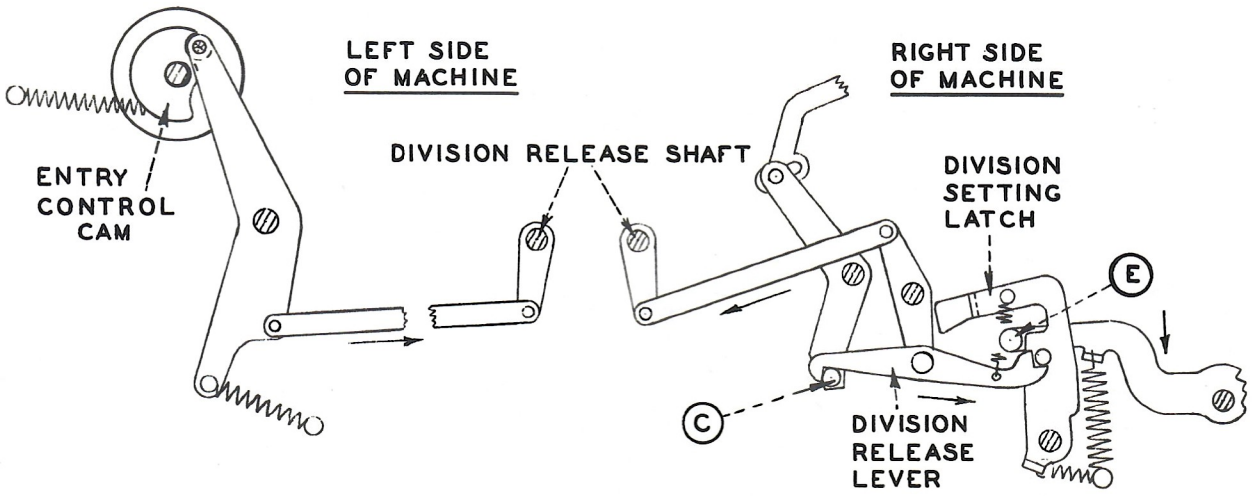


FIG. 6. TRIPPING OF DIVISION: The 6th drive shaft revolution releases the entry control gear, FIG. 4, and allows the entry control cam to restore to home position. This action causes the rotation of the division release shaft so the division release lever:

(1) reverses the counter through stud C
(2) trips the division setting latch to position the machine in division. When the division setting lever drops, stud E disables the division release lever. Division aligner operation occurs first, then standard division.

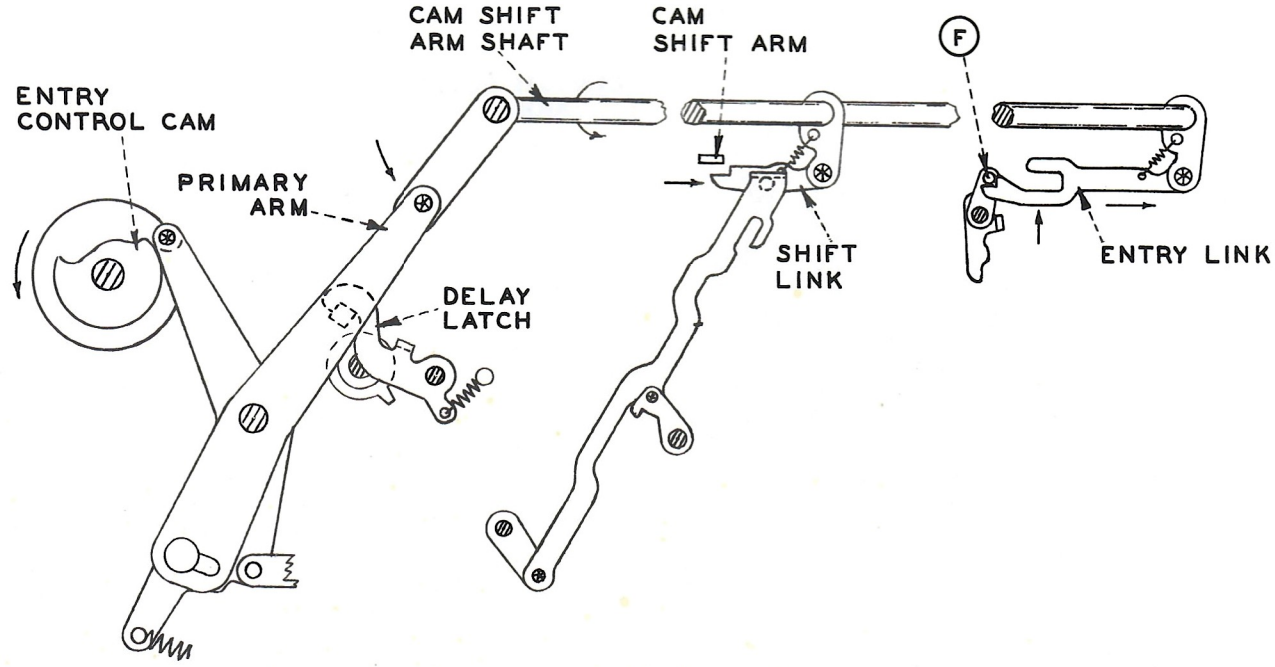


FIG. 7. LATCHING OF ENTRY LINK: On the 5th revolution of the drive shaft, the entry control cam causes the primary arm to move forward and latch onto the delay latch. The forward movement also rotates the cam shift arm shaft to:

(1) cause the forward movement of the entry link so it raises and latches onto stud F.
(2) cause the forward movement of the shift link so it will be in position to raise and engage the cam shift arm when the division mechanism is tripped.

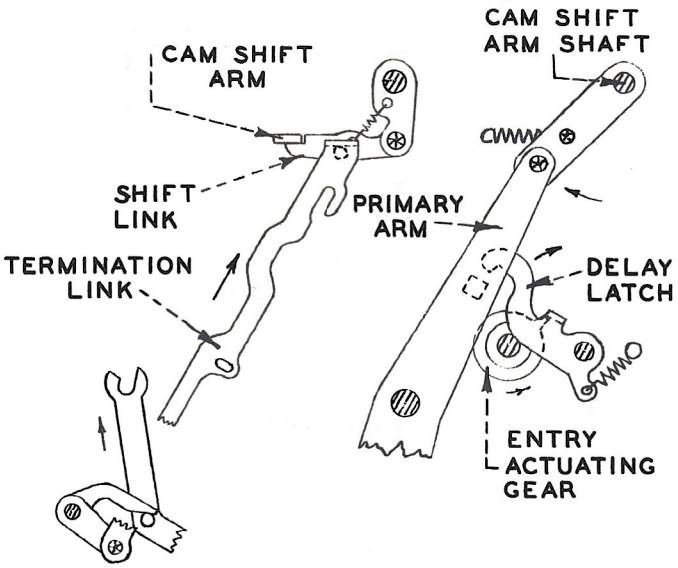


FIG. A FIG. B

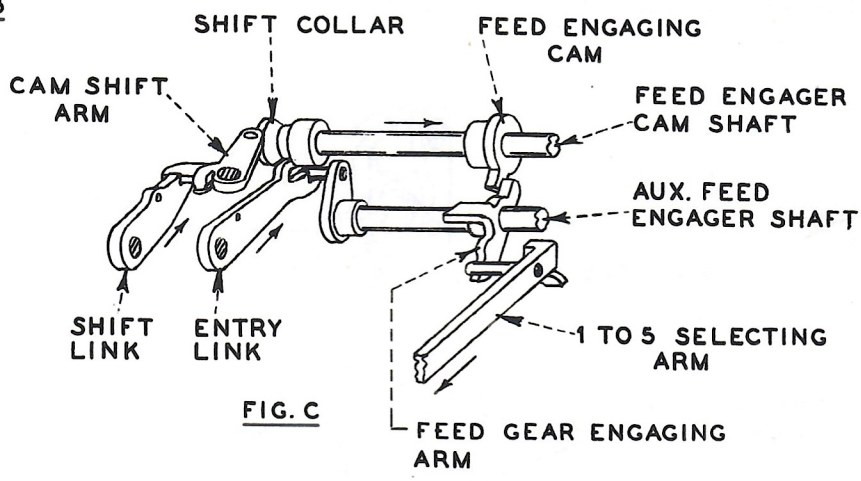


FIG. C

FIG.8. POSITIONING OF SELECTING LEVER TO INITIAL FIVE: During the 6th revolution of the drive shaft, division is tripped.

FIG. A. The termination link raises to allow the shift link to align with the cam shift arm.

FIG. B. The delay latch is delatched by the entry actuating gear to release the primary arm.

FIG. C. The primary arm is actuated by spring action to rotate the cam shift arm shaft which:

(1) causes the entry link to rotate the auxiliary feed engager shaft so the feed gear engaging arm positions the 1 to 5 selecting arm to a 5 for the initial five selection.

(2) causes the shift link to actuate the cam shift arm which in turn positions the feed engaging cams and shaft to the right. The left feed engaging cam contacts the feed gear engaging arm and restricts the full movement of the cam shaft until the feed gear engaging arm moves out of the way. When the cam shaft does move to the right, the feed engaging cam holds the initial five in through the feed gear engaging arm, and the shift collar disables the entry link.

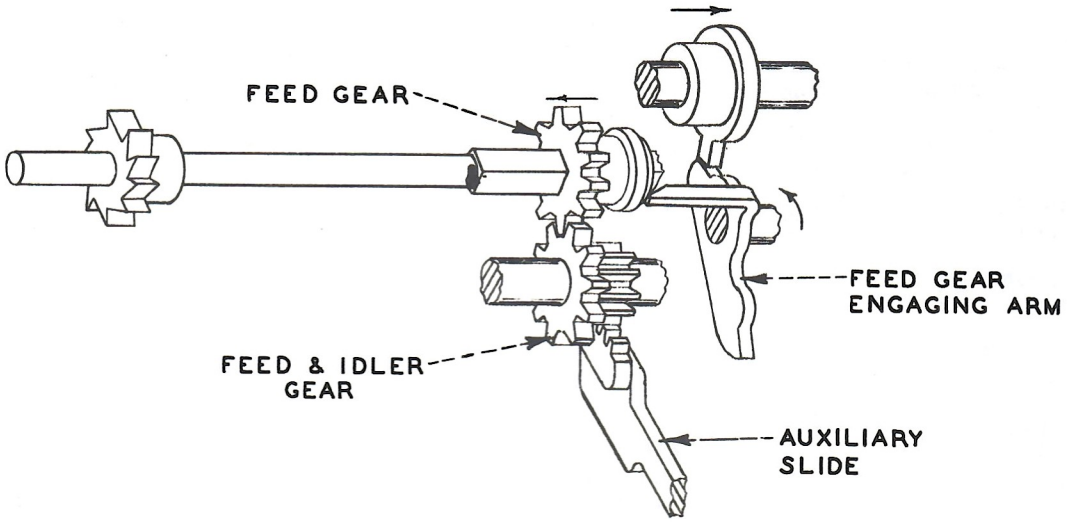


FIG. 9. MESHING OF 10th ORDER FEED AND IDLER GEARS: When the feed gear engaging arm was actuated in FIG. 8., it meshed its feed gear with the feed and idler gear of the auxiliary slide.

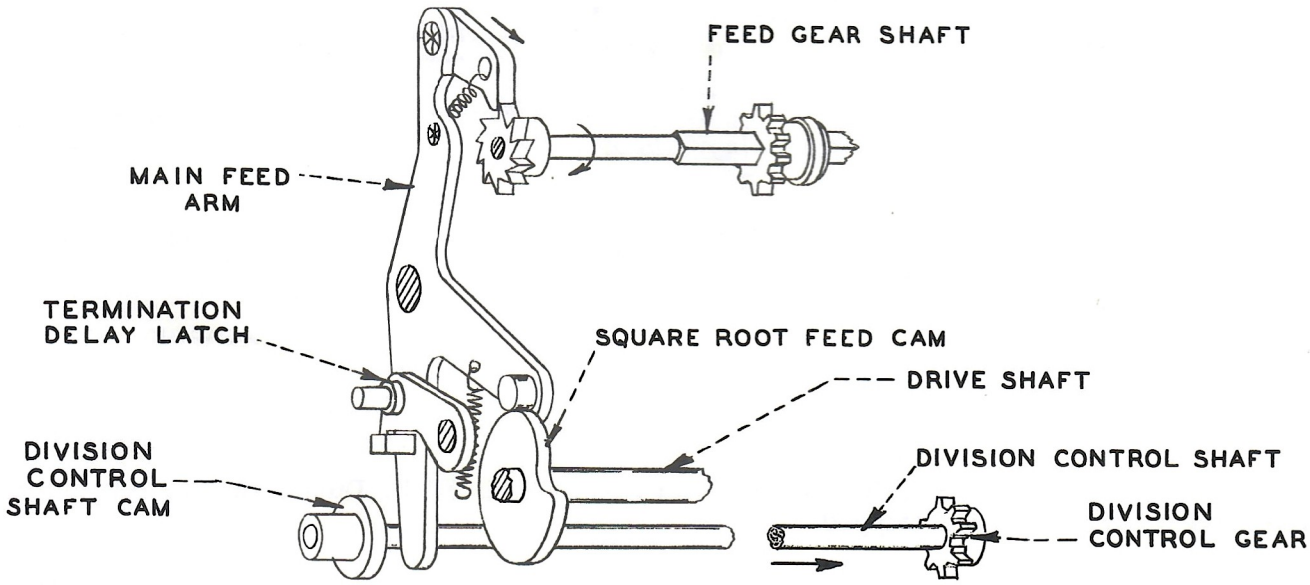


FIG. 10. FEED SHAFT OPERATION: When the division mechanism tripped, the termination link released the termination delay latch from the main feed arm; therefore, the main feed arm will follow the contour of the square root feed cam. Each revolution of the drive shaft will cause the main feed arm to rotate the feed gear shaft and feed gears one tooth space. In turn, the feed gear rotates the feed and idler gear and moves the auxiliary slide one tooth space forward to change the selection. This action continues until an overdraft occurs.

When an overdraft occurs, the division control shaft moves out and causes the division control shaft cam to block the main feed arm to stop the feeding of the feed gear shaft. The main feed arm operates only in the subtract cycles of division. In other operations of the machine, the termination delay latch prevents the operation of the main feed arm.

(For clarity, the delay latch is shown on the wrong side of the main feed arm.)

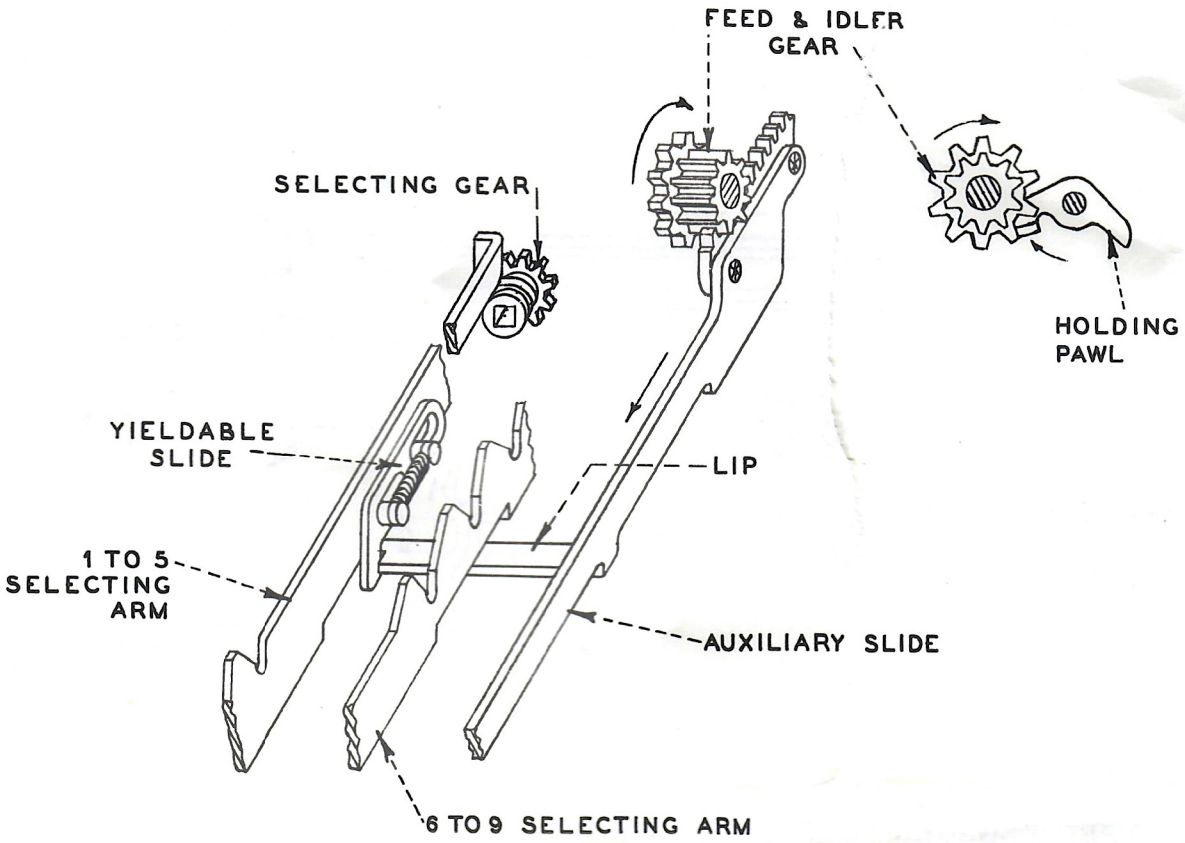


FIG. 11. POSITIONING OF AUXILIARY SLIDES: Each movement of the feed gear shaft FIG. 10, causes the feed and idler gear to move the auxiliary slide forward one tooth position. As the auxiliary slide moves forward, its lip advances the 1 to 5 selecting arm so the selecting gear meshes with the actuator segments in a 1-2-3-4-5 order with each movement of the feed gear shaft.

When the selecting arm reaches a five, the auxiliary slide can continue its forward movement because of the yieldable slide on the 1 to 5 selecting arm. The auxiliary slide lip picks up the 6 to 9 selecting arm and can move the selecting arm to a 9 selection.

As the feed and idler gear rotates, the holding pawl detents into each tooth space, thus preventing the auxiliary slide from restoring. Therefore, the selection is retained until cleared.

(For clarity, the yieldable slide is shown on the wrong side of the selecting arm.)

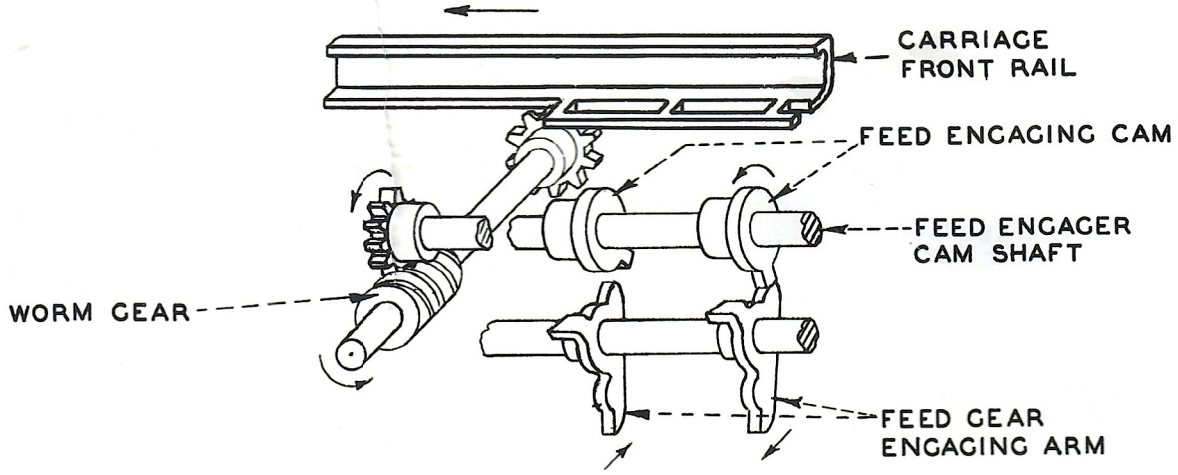


FIG. 12. FEED ENGAGER SHAFT AND CAMS: As the shift cycle of the division operation occurs, the carriage front rail causes the rotation of the worm gear of the gear box. The rotation of this gear rotates the feed engager cam shaft and causes the left feed engaging cam to disengage the feed gear engaging arm. This action allows the restoration of the 1 to 5 selecting arm positioned in FIG. 8. and the restoration of the feed gear positioned in FIG. 9.

The rotation of the feed engager cam shaft causes the next order feed engaging cam to actuate its feed gear engaging arm which:

(1) positions the next order 1 to 5 selecting arm to a 5, and,
(2) positions the next order feed gear into mesh with the feed and idler gear.

Another division subtract operation will occur. A 5 will be subtracted by the 8th column, then 15, 25, 35, until an overdraft occurs to cause a restore cycle and a shift cycle. When the shift cycle occurs the above action happens again to set the 5 selection in the next column to the right. This sequence continues until the problem is completed.

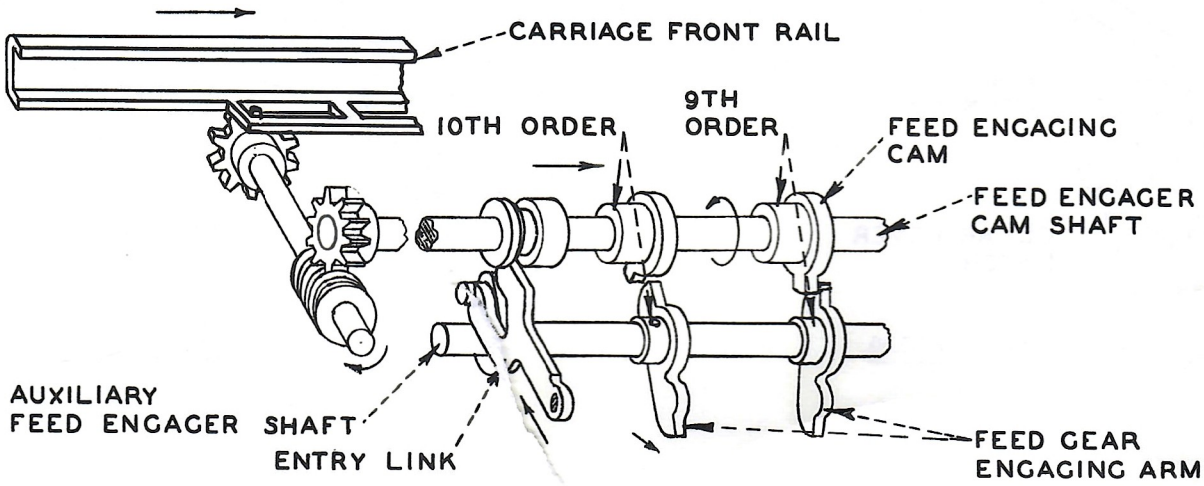


FIG. 13. FEED ENGAGER SHAFT AND CAMS - LEFT SQUARE ROOT KEY: When the left square root key is depressed, the carriage tabulates to the 8th position and the machine does the same operations as from the 9th carriage position. The entry link actuates the auxiliary feed engager shaft and the 10th order feed gear engaging arm to set the initial 5 in the selecting arm. But, the feed engager cam shaft cannot move fully to the right because the 9th feed engaging cam contacts the side of the 9th feed gear engaging arm. The machine will complete a division aligner cycle and as the carriage shifts to the right, the 9th order cam disengages from the 9th order engaging arm and the feed engager cam shaft moves to the right. The 10th order feed engaging cam moves into position to hold its engaging arm to retain the initial 5 selection, and the entry link is disengaged.

(The 10th order feed gear engaging arm is pinned to the auxiliary feed engager shaft. The other engaging arms are not pinned to their shaft.)

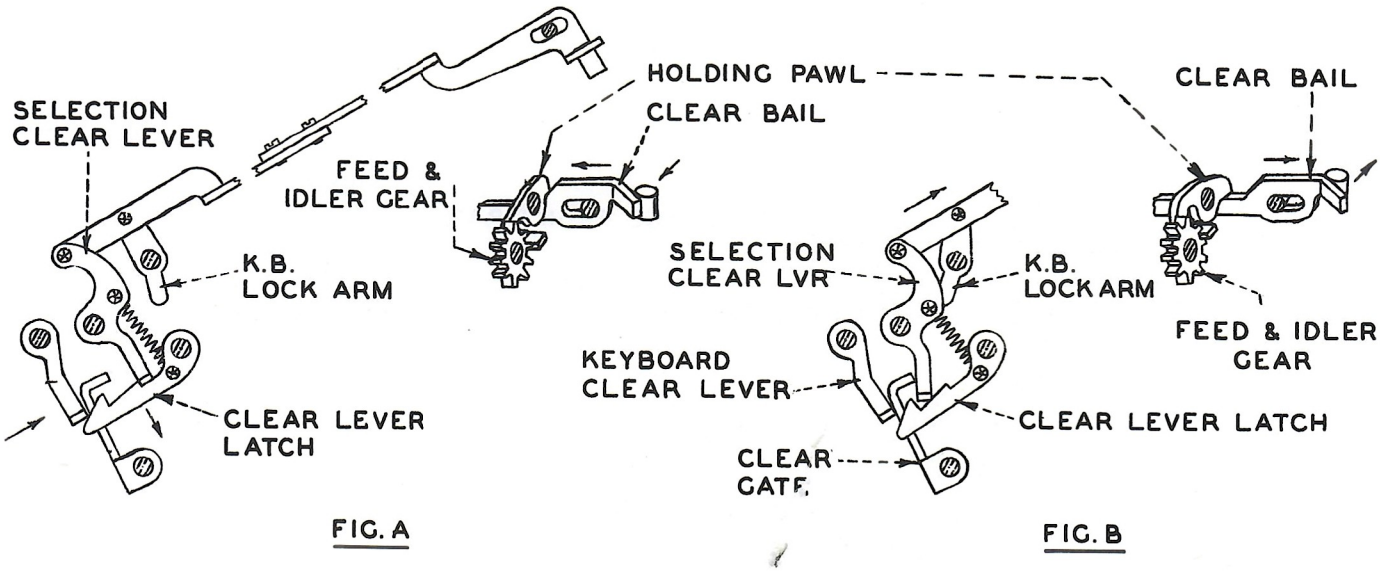


FIG. 14. HOLDING PAWL LATCHING AND DELATCHING: FIG. A. Parts are shown in home position. The clear lever latch is holding the selection clear lever; therefore, the clear bail is held to the left so the feed and idler gear holding pawls are held disengaged. The auxiliary slides are free to restore to home position.

FIG. B. The 5th entry cycle causes the keyboard clear lever:

(1) to actuate the clear gate and clear the keyboard.
(2) to depress the clear lever latch to release the selection clear lever which allows the clear bail to move to the right and cause the holding pawls to engage the feed and idler gears. The keyboard is locked by the movement of the keyboard lock arm.

When the add key is forward, the clear gate is actuated at the end of the operation and will relatch the selection clear lever. The action unlocks the keyboard, releases the holding pawls to allow the auxiliary slide to restore.

When the add key is up, the holding pawls will not be released and the keyboard will remain locked until the depression of the keyboard clear key. The selection held in corresponds to the figures in the counter dials and can be used again.

During other operations when the keyboard is used, the selection clear lever remains latched to keep the holding pawls delatched.

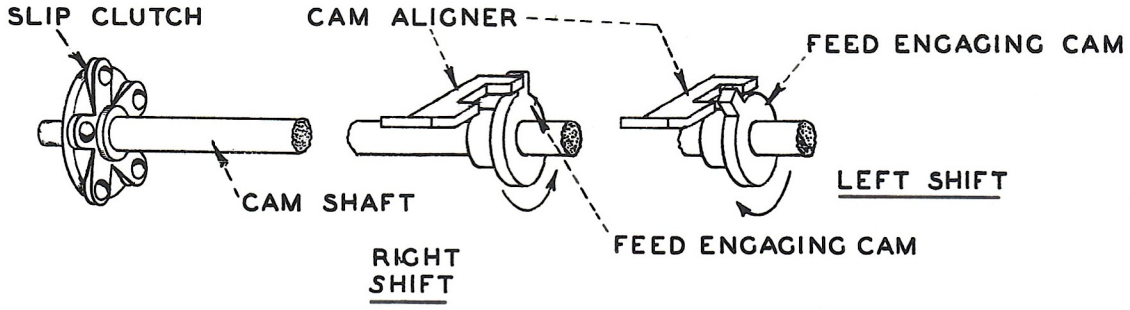


FIG. 15. CAM SHAFT SLIP CLUTCH: When for any reason the cam shaft is obstructed its slip clutch will yield until the obstruction is removed. When this occurs the cam shaft will be out of time with the carriage shift action. The cam shaft is retimed automatically whenever the carriage is shifted to the extreme right or left. These shift positions occur at the beginning of a square root problem.

The feed engaging cam will contact the cam aligner. The carriage will continue to shift to the extreme right or left and the cam shaft will be re-timed.